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Towards pervasive mobile learning – the vision of 21st century

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Abstract

Today the growth of Information and Communication Technology (ICT) has completely reshaped the area of education. Even though the traditional form of education exists today, there is a fast expansion of web based learning. It facilitates the learners to access the learning sources from anywhere, at any time. Web based learning environments includes e-learning, mobile learning and pervasive learning. Mobile learning is the union of mobile computing technologies and e-learning. This type of learning environment enables the learners to access the learning materials from anywhere at any time. Pervasive computing, also named as ubiquitous computing is a rapidly developing area of ICT. The term refers to the integration of ICT into people's lives and environments. It enables authorized access to anytime-anywhere-any device-any network-any data. Devices used in mobile learning cannot obtain the context of learners. Pervasive mobile learning is learning enhanced with intelligent environment and context awareness. While the learner is moving with his/her mobile device, the system dynamically supports his/her learning by communicating with the embedded devices in the environment. So by the integration of pervasive computing and mobile learning technologies, users are enriched with a great learning experience. This paper study about how mobile learning technologies can utilize the technology of pervasive computing so that the learning process can be made very efficient and productive. The integration of mobile learning with pervasive computing may offer great innovations in the delivery of education in the coming years.

Keywords: pervasive mobile learning; mobile learning; ubiquitous computing; e-learning; pervasive computing; omnipresent.

1. Introduction

Today the whole world is going mobile. Mobile and communication technologies are increasingly impacting the lives of individuals and are a major factor in helping reshape our culture and societies. Mobile devices connect us to a vast source of information and enables communication nearly everywhere we go. These technologies have transformed the learning methodologies also. The mobility of the individual increases the capabilities of the individuals to adapt to new learning environments. Today learning takes place at any time and at any place because of the rapid advancement in mobile technologies. Through their mobile devices, learners learn as if they are in a real classroom environment. The learning environment is equipped with sensors and other tiny devices embedded in learning objects. These devices are capable to identify the current context and other learning objects of the learners. So the learners are provided with services according to his/her context and situation. The communication between students, tutors, and instructors has increased due to the tremendous growth in these technologies. Nowadays education is no longer occurring exclusively in the traditional classroom. The traditional form of education does still exist, but the growth and expansion of ICT is so tremendous that it paved the way for the rapid development of

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Internet based learning. The Internet has radically reshaped our higher education area. Today Internet-based teaching is an opportunity for millions of students to receive their education. It is not too expensive to use the Internet for study, and the courses provide excellent tools like message boards, chat rooms, etc.

Pervasive computing is becoming commonplace and has a huge influence in the way in which individuals relate with others and their surroundings. Mobile learning has become more popular with the advent of pervasive computing technologies. A pervasive environment utilizes context-aware applications to deliver the learning materials depending on the user context. Pervasive devices are able to sense the environment and can offer efficient services to learners [10]. Depending on the location, learners can exploit the resources/services in his/her neighbourhoods [10]. The learning materials available in the net can be accessed easily using hand-held devices like laptops, PDA and mobile phones [7]. Recent developments on mobile devices and pervasive computing enable new opportunities for mobile learning users. In the near future, even learners don't need to carry the mobile devices; the environment itself will guide them to avail the services as per the user's needs. Mobile learning helps in the development of knowledge society [12]. The objective is a society with access to knowledge and learning for everyone [11].

The paper is structured as follows: In Section 2, technological innovations in learning is explained followed by the significance of mobile learning in Section 3. Section 4 addresses the objective of this paper which explains the pervasive mobile learning, application of pervasive technologies in mobile environment scenarios and challenges in the area. Finally we conclude in Section 6.

2. Technological Innovations in Learning

One of the very early adopters of new technological innovations is the field of education. As new technologies are shaping around, a lot of resources are invested to improve the process of teaching and learning. Learning is fundamentally a process of communication. It is acquiring new knowledge, behaviors, skills, values, preferences or understanding, and may involve synthesizing different types of information [23]. Over the years advancements in the learning process are greatly influenced by the latest developments in ICT, thus making it more efficient and productive [15].

New technologies are being adopted in teaching and learning processes. But still traditional learning is a key model in learning where the teacher has face-to-face interaction with the students [7]. The focus is on the teacher who is standing in front of a classroom. A blackboard, an overhead projector, a video projector and occasionally Internet access for instructors are provided in a classroom. This type of learning has a cultural effect because students are able to interact and learn from one another. Also the relationship between the students and the teacher is very strong [14]. But lack of efficient classroom equipments, accessibility of the location, and the limitation of class rooms are the major disadvantages of traditional method. So in many educational institutions e-learning and mobile learning have gained attraction in the recent years because the students are able to access the learning sources from anywhere, at any time on all these web-based learning environments [9].

The early advance in the field of education in the 20th century was to design and broadcast a number of educational programs through radio and TV [8]. Later learning materials were produced and delivered in digital form instead of the printed form. The next phase was the arrival of multimedia and hypermedia technologies, enabling the delivery of learning materials through CD ROMs thereby improving the effectiveness of learning [7]. The advantage of these educational CDs was that it can be customized and reused according to the learner's needs.

Rapid development of Internet and WWW lead to web based learning environments. It provided tremendous opportunities for learning. In mid 90's, a number of web based learning environments like e-learning systems were developed [8]. It comprises all forms of electronically supported learning and teaching [16]. Mobile learning is e-learning through mobile computational devices like Palmtops, Personal Digital Assistant (PDA), cell phones etc. So even though face-to-face interactions are missing in these models, high-quality learning contents and better delivery mechanisms made them attractive than the traditional classroom approach [8]. Since the price of mobile devices has dropped, they are extensively used in our lives [12]. Nowadays hardly you can find a person without a mobile device. The learning form is gradually promoted from e-learning to Mobile learning to Pervasive Learning. So in this e-Society, the knowledge acquired at schools and universities may be insufficient for the whole life span.

3. Significance of Mobile Learning

Mobile Learning (M-Learning) is: Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies [13]. It creates an environment of anywhere, anytime learning [1] [2] [3]. It is now a routine for business people and educators to carry laptops, mobile phones, and personal data assistants that allow them to collect data anywhere; whether in a conference room, a classroom, or a car. Now many people not only own a desktop/ laptop, but also either a cell phone/PDA/MP3 player. Wireless-enabled devices and video conferencing systems allows students in various locations to meet online so that they could exchange ideas and feedback with their peers and instructor. The students are in different locations, yet they interact with one another through wireless connectivity. They could send and receive e-mail messages, engage in real-time document collaboration, exchange graphics, and transfer files. This is a revolutionary change from the traditional way of classroom learning.

Mobile Learning is intended for those people who were not able to undergo traditional education. Mobile learning decreases limitation of learning location with the mobility of general portable devices. It has shattered the requirements for students to be seated for lengthy periods at a given time and place. It enables students to take courses at their convenience. The complete independence of both location and time is possible. Since students could access and verify information online it boosted their efficiency. They could cite relevant information quickly and continue working on their drafts. Moreover, wireless network access to the Internet increased students' mobility because it allowed them to carry their laptops around.

4. Pervasive Mobile Learning

Pervasive computing, also named as ubiquitous computing is a rapidly developing area of ICT. The term refers to the integration of ICT into people's lives and environments. It enables authorized access to anytime-anywhere-any device-any network-any data. In 1991, Mark Weiser, a researcher at Xerox PARC, coined the term 'Ubiquitous Computing' [19]. His vision for the 21st century was "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" [17]. He predicted that the technology itself will become invisible and networked into our daily lives. The hardware to support pervasive computing was not available at that time. But still he envisioned a future where tiny devices will be embedded in the environment making the pervasive computing a reality. And now the unbelievable growth in hardware technology has fulfilled his vision.

In mobile learning, devices such as PDA, mobile phones, and so on are connected to Internet with wireless communication technologies like WiFi, BlueTooth etc, and this enables the learning at anytime and anywhere [20]. But the devices cannot obtain information about the context of his/her learning. Pervasive Mobile Learning is learning enhanced with intelligent environment and context awareness. The information about the learner's context is obtained from the learning environment which is embedded with sensors, tags and so on. While the learner is moving with his/her mobile device, the system dynamically supports his/her learning by communicating with embedded devices in the environment.

Mobile devices, embedded systems, wearable computers, sensors, Radio Frequency Identification (RFID) tags, etc make the environment pervasive. Devices embedded with microprocessors are used to sense our movements [19]. So apart from distance and time, pervasive computing provides users with the ability to access information. It provides the possibilities of embedding computational support for the learning activity in the learner's physical contexts [18]. These environments can be built either by embedding models of a specific environment into dedicated computers, or use computers to inquire, identify, search, and dynamically build models [27].

4.1 A pervasive(smart) classroom model

Smart Space is a key feature of Pervasive Computing. They are ordinary environments equipped with visual and audio sensing systems that can perceive and react to people without requiring them to wear any special equipment. Pervasive devices, sensors, and networks, provide infrastructure for smart spaces that sense ongoing human activities and respond to them. Smart Space provides a better experience for mobile learning users. Pervasive devices are typically tiny, even invisible. So they can be portable and carried around just like mobile devices. They can be hidden in the learning environment without being noticed thus making the space smart [7]. Mobile devices

roaming with users can determine the existence of smart space and can spontaneously take use of the resources and the services in the space to perform user's tasks.

Classrooms based on smart space enables the teacher and the students to have better teaching and learning process [7]. It combines the traditional education with the web-based one thereby allowing the teacher to teach using a variety of media. The main features of a smart classroom includes natural user interface, automatic capture of classroom events and experience, context-awareness and joint work support [29]. Pervasive computing technologies allow the use of voice, gesture, eye-gaze, facial expressions etc thereby making the user interface more natural. In traditional distance-education systems, audio/video of lecture was recorded for broadcasting purposes. But here it is not just the recording of audio/video of the environment; it includes all the events and experiences that happened in the environment. Devices in the environment are smart enough so that they are able to perceive the user context so as to provide the services wherever they may be. With this hi-tech advance, multi-user and multi-device can be achieved.

Figure 1 gives an overview of the Smart Classroom. It is designed to accommodate both local and remote students. A *Smart Board* is employed in the classroom for the teacher's use to display the teaching notes or to annotate. A *Student Board* can be used to display the details of the remote students. A series of software modules supports this environment. These modules control the overall behaviour of the classroom. Local students participate in the lecture with their desktops/laptops and the remote students can access the environment with their mobile devices. Here the teacher deliver his/her class while moving freely and using conventional teaching methods to train both the local as well as the remote students' simultaneously. With the help of pervasive devices (sensors) the remote students can get the real feeling that they are attending the class room physically. The teaching notes and audio/video materials can be captured and can be easily transmitted to student's electronic devices [29]. So the learning environment becomes interesting.

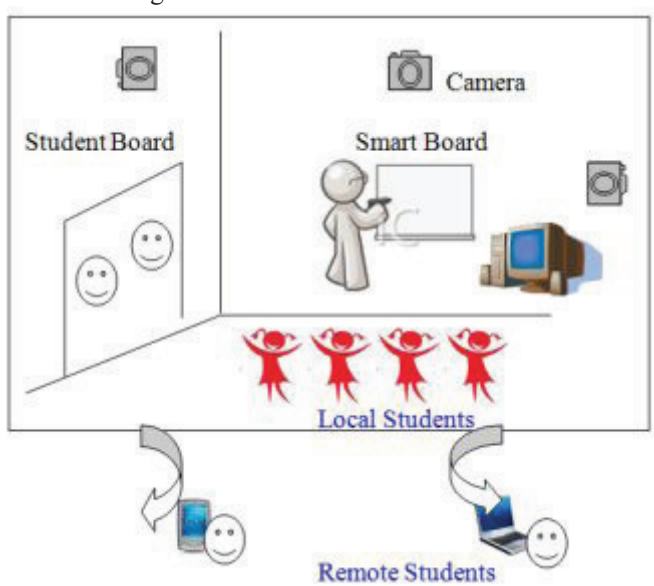

Figure1. A pervasive (smart) classroom model

4.2 Scenarios

Scenario 1 – A smart learning environment.

Assume that an educational institution in Dubai [Main Branch] is planning to open sub-branches in Sultanate of Oman and Bahrain. The learning environment is made pervasive and students in different places are able to attend the lectures delivered in Dubai campus.

The students registered for a particular course are intimated about the course schedule and timings by the Main branch. The classroom in the Main branch is equipped with audio and video sensing systems. Also it integrates different modules to make the learning environment smart. A "*lecture_intimation* module" is responsible for informing the students about the start of every lecture of a particular course. The identity of the student [local and remote] is verified by another module say, "*identification* module" so as to access the learning environment. Upon

verification of the credentials, the student will be provided with an immediate confirmation that he/she has successfully joined the environment. The person who is identified as teacher is granted automatically, the rights to control the class. The teacher starts the lecture by speech like "*Today we will learn Chapter 4 of Introduction to Programming course*", then automatically the lecture notes of that particular chapter are displayed in the corresponding screen, which is situated in the classroom of the Main branch.

Pervasive devices capture the notes and deliver them to student's devices. Students are able to annotate on these notes. The local as well as remote students participate in the classroom discussions. Also if some announcements are posted in the Notice Board of the main branch, with the help of smart pins, the sensors in the environment detect the presence of the announcement and the corresponding announcement is send to the student's mobile devices. So here the underlying principle of pervasive computing to make information available everywhere and anywhere at any time is satisfied.

Scenario 2 – Application of pervasive technologies in a college/university

Assume that a person is coming to a college/university. He/She owns a mobile device and is new to the environment. If the surroundings are smart, it can guide him/her to navigate the college. People those who are part of the college/university can also benefit from the smart environment.

When the person enters the campus, a sensor identifies his/her presence. Brief information about the college, like details of departments, programmes/courses offered by various departments, student support services etc are displayed in his/her mobile device. Accordingly he/she can proceed with the purpose of visit or can avail the services offered by the college/university. Here the data is present in the embedded objects in the environment. It can be transferred to the student in the form of images, text, sound or other format. Also this information is flexible and adaptable, allowing updates to be applied through a database.

Existing staff/students of the institution are identified automatically by matching their credentials stored in the database server against their ID card. Once the person is identified, a floor plan of the building is displayed with a list of services available in the campus. The services include *printer services*, *room_locating services* etc. For example if a student wants to take a printout of their assignment, the smart objects in the environment try to find a suitable printer near to his/her location with the help of sensors. The student starts the print job on his/her notebook. The job is sent to the printer and when the task is finished he/she is informed the same with necessary guidelines to direct the student to the location of the printer to collect the document. Similarly students can locate free-access labs/ lecture rooms within the campus. Also if the time/ venue of a particular lecture are changed, students/staff will be informed about the changes.

In pervasive learning environments, the emphasis is fundamentally on the learning dimensions rather than the technical aspects, but close cooperation among technical experts, educators and researchers is very important to truly persuade learning [15]. A learner can take learning opportunities directly in the situation where they occur, because he has his learning environment always at hand. The shape of knowledge is decided by the learner. The learning potentials in pervasive environments have begun to emerge. Researchers all over the world conduct researches, perform experiments to examine the use of pervasive computing technology in the learning process.

4.3 Implementation Challenges

Pervasive Computing opened new dimensions to learning methods. The limitations of pervasive mobile learning are a combination of technical and educational challenges. There is a need for middleware, networking and a software framework for interaction among the various pervasive devices that together constitute the learning environment. Some of these disadvantages may disappear as technology improves.

- *Developing Learning Models to support Pervasive learning*

There are several learning models that are suitable for different learning activities in pervasive learning environments, but none of them was validated properly.

- *Middleware and System Support*

Pervasive computing middleware is a software architecture that acts as an intermediary between applications, processes, services and devices in changing computing spaces. A number of systems have been proposed using the concept of service discovery. But still this area needs further progress to have a system which supports interoperability and incompatibility among devices in a pervasive environment. The mobile market contains lots of different devices without much standardization, which leads to a need for detailed technical knowledge to be able to integrate mobile technology in existing learning scenarios. Moreover, the rapidly changing technologies form an additional burden to keep the learning scenarios up-to-date. Other issues include limitations on the screen size, battery life, keypad interfaces etc of the mobile devices used.

- *Privacy & Security*

Hundreds of clients and services exist in a pervasive environment. Entities that are supported on a pervasive computing framework may provide services that collect data. Personal information can be disclosed when clients are looking for services and when service providers are providing the services. This data may be private and confidential to a user. Entities that collect data may be able to exchange it freely without any authorization or authentication [28]. So it is really a big problem from the user's point of view to have a compromise on privacy and security.

5. Conclusion and Future

The paper focuses on the success of pervasive mobile learning environments. The assimilation of pervasive computing in mobile learning marks a great step forward. This new technology has changed the traditional concept of learning so that we are being frequently surrounded by, and immersed in learning experiences. When wearable computers and embedded microchips were portrayed in early movies, people were not ready to believe that in future these technologies will become a reality. Innovations like telephone, television, computer, mobile phones, etc were like that; first they appeared strange but eventually they were incorporated into our everyday lives.

Learning through mobile devices has enhanced a lot with the advent of pervasive computing technologies. In this age of progress and great change, we tend to easily adapt to the technologies and pedagogies that emerge. So the integration of mobile learning with pervasive computing may offer great innovations in the delivery of education in the coming years. In future, applications will be developed so as to enable learners to start a task with their PDA and later shift the location and continue the task with his/her mobile phone and later revert it to PDA to finish it. Even the recent developments in mobile technologies foresee a day where learners don't even need a device to learn.

There is a time and place for learning; it should be a learner's time and place [6].

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